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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/766,886	01/30/2004	Tatsuya Usami	8001-1190	4182

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EXAMINER	
PAREKH, NITIN	

ART UNIT	PAPER NUMBER
2811	

DATE MAILED: 04/13/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	10/766,886	USAMI, TATSUYA
	Examiner	Art Unit
	Nitin Parekh	2811

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08 March 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-16* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *01-30-04*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Election/Restriction

1. Applicant's election of Group I, claims 1-16 of Embodiment I, without traverse in Paper No. 3 is acknowledged.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 1-9, 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jain et al. (US Pat. 6417092- see IDS) in view of admitted prior art (APA).

Regarding claims 1-3, 12 and 13, Jain et al. disclose a semiconductor device, wherein:

- a low-k dielectric film/interlayer dielectric film (IDF) is provided on a base layer (see 16 in Fig. 1a-1h; Col. 4, lines 18-22) including semiconductor substrate

- an etch stop barrier material comprising a hydrogenated silicon carbon nitride film/SiCHN film containing silicon, carbon, hydrogen and nitrogen being formed on the low-k dielectric film/IDF (see 15 in 1a-1h; Col. 1, line 65- Col. 2, line 7), such two layer structure comprising the IDF/barrier layer further including a plurality of desired levels of stacked layers to form a multilevel device/MLD (Col. 4, lines 15-64), and
- an electrically conductive film containing copper (Cu) as a main component element is embedded in a trench formed in the low-k dielectric film/IDF (see 24 in a two layer structure of Fig. 1h; Col. 4, line 50) such that the SiCHN film is formed on/to cover the electrically conductive film to form the plurality of stacked layers of the MLD (multilevel structure not shown in Fig. 1h- see Col. 4, lines 59-64)

(Fig. 1a-1h; Col. 1, line 65 – Col. 4, line 65; Col. 1-5).

Jain et al. fail to teach the IDF having Si-H bonds.

The APA teaches conventional low-k IDF comprising ladder oxide (L-Ox)/L type hydrogenated polysiloxane material having Si-H bonds to provide the desired low-k value and adhesion (see specification pp. 2).

It would have been obvious to a person of ordinary skill in the art at the time invention was made to incorporate the IDF having Si-H bonds as taught by the APA so

that the dielectric constant value can be achieved and the adhesion can be improved in Jain et al's device.

Regarding claims 4-9, Jain et al. and APA teach substantially the entire structure as applied to claims 1-3 above, wherein Jain et al. further teach the SiCHN film having a Si in a range of about 15-40 at.%, C in a range of about 20-40 at.%, N in a range of about 2-20 at.% and H in a range of about 25-55 at.% (Col. 1, line 65- Col. 2, line 15), but Jain et al. and APA fail to teach the SiCN film having nitrogen concentration being in a range of about 10-35 at.% or 15-30 at.%.

The determination of film parameters such as elemental composition/at.%, Si-H/Si-O bond ratio, dopant distribution within the film, etc. etc. in chip packaging and interconnect technology art is a subject of routine experimentation and optimization to achieve the desired final properties including dielectric constant, hardness/porosity, etch resistance, etc.

It would have been obvious to a person of ordinary skill in the art at the time invention was made to select the SiCN film composition having nitrogen concentration being in a range of about 10-35 at.% or 15-30 at.% so that the desired elemental distribution among silicon, carbon and nitrogen to provide the optimized etch resistance, diffusion barrier and adhesion in the APA and Jain et al's device.

4. Claims 10 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jain et al. (US Pat. 6417092- see IDS) and the APA as applied to claims 1-5 above, and further in view of Xu et al. (US Pat. 2003/0077916).

Regarding claims 10 and 11, Jain et al. and APA teach substantially the entire structure as applied to claims 1-5 above, except the SiCN film having oxygen (O) being in a range of about 0.5-5.0 at.%.

Xu et al. teach a silicon and carbon containing barrier film/SiC further comprising oxygen and nitrogen doped film having Si, C, H, N, O/SiCHON composition wherein the oxygen content about less than 10 at.% (sections 0023-0025).

Furthermore, the determination of film parameters such as elemental composition/at.%, Si-H/Si-O bond ratio, dopant distribution within the film, etc. etc. in chip packaging and interconnect technology art is a subject of routine experimentation and optimization to achieve the desired final properties including dielectric constant, hardness/porosity, etch/oxidation resistance, etc.

It would have been obvious to a person of ordinary skill in the art at the time invention was made to select the SiCN film having the oxygen being in a range of about 0.5-5.0 at.% as taught by Xu et al. so that the desired elemental distribution among silicon, carbon, nitrogen and oxygen to provide the optimized etch/oxidation resistance, diffusion barrier and dielectric constant can be achieved in the APA and Jain et al's device.

5. Claims 14 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jain et al. (US Pat. 6417092- see IDS) and the APA as applied to claims 1 and 2 above, and further in view of Liu et al. (US Pat. 2004/0048468).

Regarding claims 14 and 15, Jain et al. and APA teach substantially the entire structure as applied to claims 1 and 2 above, except:

a) a metal nitride film is provided between the dielectric film and the electrically conductive film containing Cu as a main component element and a metal film is provided between the electrically conductive containing Cu as a main component element and the metal nitride film, and

b) the electrically conductive film containing Cu as a main component element is Cu alloy film containing at least one kind selected from the group consisting of Al, Si, Ag, W, Mg, Bi, Zn, Pd, Cd, Au, Hg, Be, Pt, Zr, Ti and Sn.

Liu et al. teach a conventional copper interconnect structure comprising:

- an electrically conductive material/film such as Cu/Cu alloy film containing Al (see section 0026), and
- a stack of a variety of barrier layers including a metal/metal nitride such as Ti/TiN:W (see 15 in Fig. 1; section 0033-0035).

It would have been obvious to a person of ordinary skill in the art at the time invention was made to incorporate elements a) and b) as taught by Liu et al. so that the diffusion barrier and electrical performance/reliability can be improved in the APA and Jain et al's device.

6. Claim 16 is rejected under 35 U.S.C. 103(a) as being unpatentable over Jain et al. (US Pat. 6417092- see IDS) and the APA as applied to claims 1 and 2 above, and further in view of Noguchi et al. (US Pat. 2002/0042193).

Regarding claim 16, Jain et al. and APA teach substantially the entire structure as applied to claims 1 and 2 above, except the electrically conductive film containing Cu as a main component element is a Cu alloy film containing Si and the Si content is highest on a top surface of the electrically conductive film and gradually decreases with increasing depth in the direction of a bottom surface.

Noguchi et al. teach a copper interconnect structure having Cu as a main component within a trench (see Fig. 67) wherein the Cu/Cu alloy contains Si which is distributed within the Cu/Cu alloy plug such that the Si content is highest on a top/around top surface (see Si content at d=10-60mm in Fig. 67 for NH3/H2 plasma; sections 0340 and 0342) and gradually decreases with increasing depth (see Si content at d=90-300mm in Fig. 67 for NH3/H2 plasma; sections 0340 and 0342) in the direction of a bottom surface.

It would have been obvious to a person of ordinary skill in the art at the time invention was made to incorporate the Cu alloy film containing Si such that the Si content is highest on a top surface and gradually decreases with increasing depth in the direction of a bottom surface as taught by Noguchi et al. so that the Cu alloy impurity level can be reduced and the surface cleanliness can be improved the APA and Jain et al's device.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nitin Parekh whose telephone number is 571-272-1663. The examiner can normally be reached on 09:00AM-05:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie Lee can be reached on 571-272-1732. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9318.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Nitin Parekh

NP

NITIN PAREKH

04-09-05

PRIMARY EXAMINER

TECHNOLOGY CENTER 2800